METEOROLOGICAL OFFICE

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Agricultural Memorandum No 902

Further investigation of relationships between day, night and 24-hourly averages of temperature, wind-speed and vapour pressure

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Introduction

In Agricultural Memorandum No 844 the use of a stability index, $^{n}/_{N}$, to describe differences between day-time and night-time values of wind-speed, temperature and vapour pressure deficit was discussed.

Data for each of the following variables were found for each month and plotted against $^{n}/_{N}$ (n = hours of bright sunshine, N = maximum possible hours of sunshine).

(a) $(T - T_{24})$ where T = day (or night) average temperature
T_{24} = 24 hour average temperature

(b) $\frac{U}{U_{24}}$ where U = day (or night) average wind-speed
U_{24} = 24 hour average wind-speed

The data were taken over a ten year period (1968 to 1977) at Prestwick.

On these graphs the best straight line was fitted to the points by eye, and the gradient and intercept of each line were found.

This technique has now been improved to take in more than one station and to eliminate the uncertainty involved in fitting a straight line by eye by using a linear multiple regression approach.

Method

Three stations were used, Elmdon, Heathrow and Prestwick. The 24 hourly average, the day-time average and the night-time average of each of the following were taken for the ten year period 1969 to 1978:

1. Temperature
2. Wind-speed
3. Vapour Pressure

The wind-speed ratio ($^{U}/_{U_{24}}$), temperature difference ($T-T_{24}$) and vapour pressure ratio ($^{VP}/_{VP_{24}^{*}}$) were plotted against $^{n}/_{N}$ for day and night values of U, T, and vapour pressure, for each month (see examples in figures 1 and 2). The straight line was found by computer using the 'least squares method'. The wind-speed ratio and temperature difference are shown in figures 3 and 4. It can be seen that there is good agreement in these values between the stations.

(* Here VP_{24} is the 9Z value for vapour pressure)

The vapour pressure ratios, which are given in the appendix, were found to differ very little from unity and so were not considered to be significant, i.e. the 9Z vapour pressure values are a good approximation to day and night averages.

The slope and intercept of the straight line were found for the wind-speed ratio and the temperature difference; these are shown in figures 5, 6, 7 and 8. In figures 6 and 8 the average intercept for Heathrow, Elmdon and Prestwick is given, because the individual intercepts were almost identical.

Results

1. Temperature

From figures 7 and 8 it can be seen that the day-time values of slope and intercept for temperature are fairly constant throughout the year. The variations in gradient between stations are of the same order as the monthly variations, so we are justified in taking a value averaged for the three stations over the whole year.

The average value for the slope is 1.4

The average value for the intercept is 0.7

For the night-time values of slope and intercept the trend is rather different and we are not justified in taking a constant value for slope and intercept. Better results are obtained if the year is divided into two seasons, April-September inclusive, and October to March.

This gives the following values:

April-September; slope = -2.7
intercept = -1.0

October-March; slope = -0.9
intercept = -0.5

For completeness, separate monthly values for slope and intercept are included in the appendix.

2. Wind-speed

During the day, as for temperature, an average value for slope and intercept can be taken. These are:

Slope = 0.1
Intercept = 1.1

The night-time values have a more significant trend but the errors are such that it would be unrealistic to take monthly values and an average value was taken for the slope and the intercept. These were:

Slope = -0.1
Intercept = 0.9

3. Vapour Pressure

The day-time and night-time values of vapour pressure were found to differ very little from the 9Z value.

Conclusions

From these results we can produce equations which describe the relationship of day and night-time wind-speeds and temperatures to the 24 hour average value.

These equations are:

Temperature: $T_{day} - T_{24} = 1.4\ {}^{n}/_{N} + 0.7$

$T_{night} - T_{24} = -2.7\ {}^{n}/_{N} - 1.0$ (April-Sept)

$T_{night} - T_{24} = -0.9\ {}^{n}/_{N} - 0.5$ (Oct-Mar)

Wind-speed: $\frac{U_{day}}{U_{24}} = 0.1\ {}^{n}/_{N} + 1.1$

$\frac{U_{night}}{U_{24}} = -0.1\ {}^{n}/_{N} + 0.9$

Suggestions for further work

If these equations are to provide a means of estimating day-time or night-time temperatures and wind-speeds for any station for any month a more comprehensive set of data is needed; more than three stations, perhaps a dozen, and readings over a longer period of time, should be used. The stability index ${}^{n}/_{N}$ is of a very simple form, and could possibly be improved.

Any comments or suggestions on this paper should be referred to the Authors.

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References

G Wright 'Relationships between day, night and 24-hourly averages of certain Penman variables'. Agricultural Memorandum No 844.

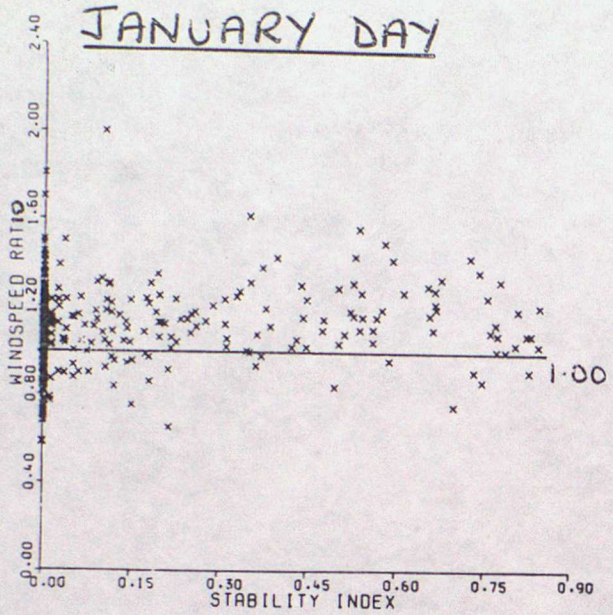
	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
$\frac{VP_{day}}{VP_{24}}$	1.04	1.04	1.01	0.99	1.0	1.0	0.99	0.97	0.99	1.02	1.05	1.04
$\frac{VP_{night}}{VP_{24}}$	1.02	1.01	0.98	0.99	0.98	0.99	0.99	0.97	0.97	0.98	1.01	1.02
TEMP SLOPE DAY ^{o}C	1.14	1.31	1.74	1.36	1.48	1.27	1.32	1.83	1.83	1.86	1.08	0.68
TEMP SLOPE NIGHT ^{o}C	-0.58	-0.92	-1.56	-1.94	-2.94	-3.35	-3.08	-2.95	-2.12	-1.48	-0.55	-0.35
TEMP INTERCEPT DAY ^{o}C	0.52	0.65	0.75	0.72	0.58	0.45	0.51	0.60	0.83	0.91	0.89	0.59
TEMP INTERCEPT NIGHT ^{o}C	-0.23	-0.40	-0.68	-1.00	-1.09	-1.07	-1.02	-0.92	-0.85	-0.65	-0.45	-0.36
WIND-SPEED SLOPE DAY	0.04	0.10	0.16	0.10	0.11	0.06	0.06	0.12	0.14	0.15	0.07	0.01
WIND-SPEED SLOPE NIGHT	-0.06	-0.06	-0.14	-0.15	-0.21	-0.17	-0.15	-0.19	-0.16	-0.12	-0.03	0.0
WIND-SPEED INTERCEPT DAY	1.08	1.09	1.11	1.01	1.06	1.07	1.07	1.08	1.11	1.13	1.09	1.06
WIND-SPEED INTERCEPT NIGHT	0.97	0.94	0.91	0.89	0.89	0.85	0.86	0.89	0.90	0.92	0.96	0.98

FIGURE 1

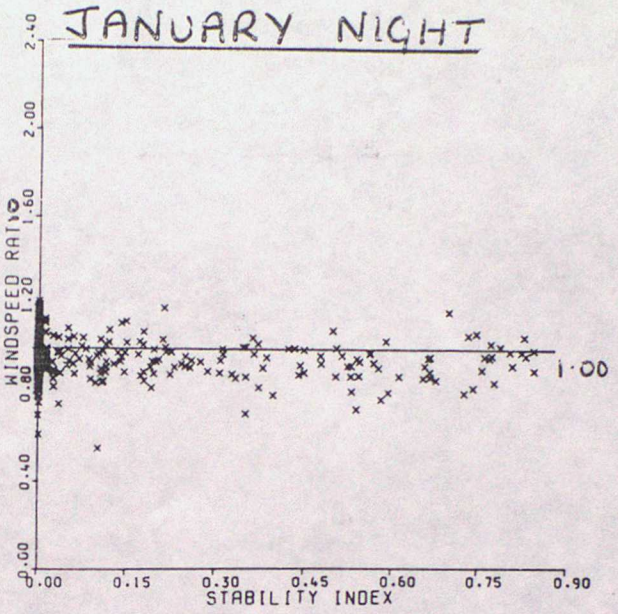
WINDSPEED RATIO AS A FUNCTION OF σ/N

FOR ELMDON

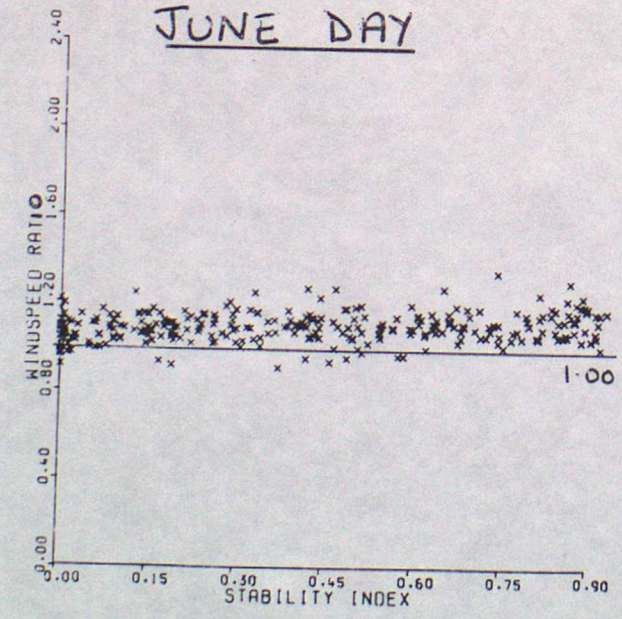
JANUARY DAY



JANUARY NIGHT



JUNE DAY



JUNE NIGHT

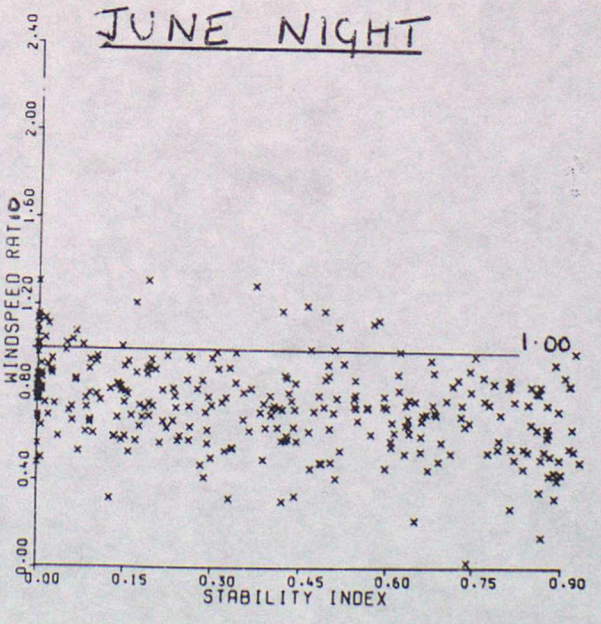
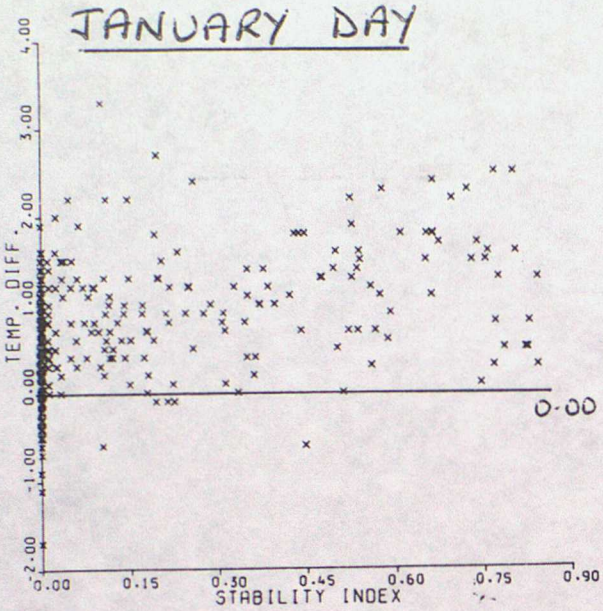


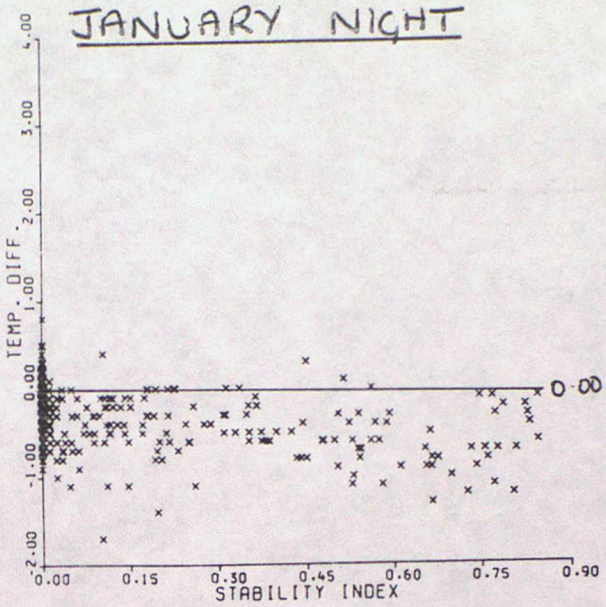
FIGURE 2

TEMPERATURE DIFFERENCE AS A FUNCTION OF Ri/N FOR ELMDON

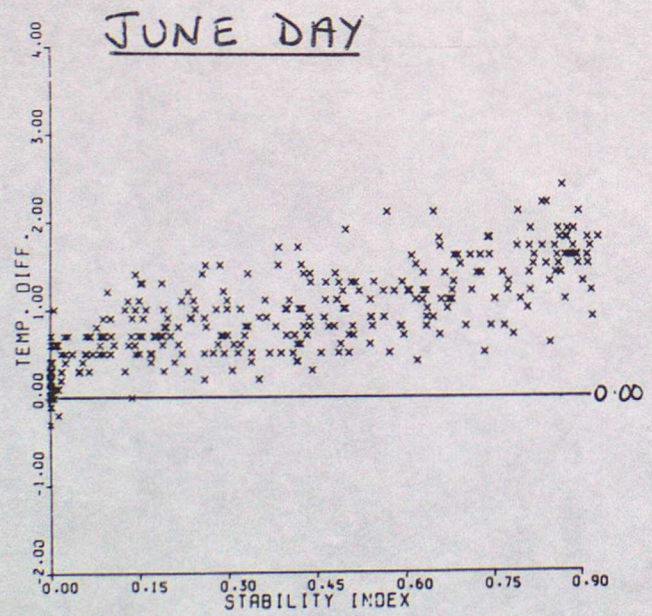
JANUARY DAY



JANUARY NIGHT



JUNE DAY



JUNE NIGHT

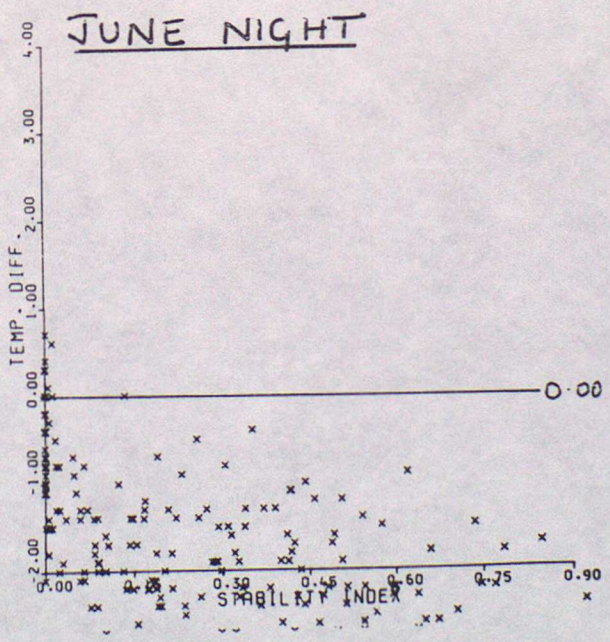


FIGURE 3

WINDSPEED RATIO THROUGHOUT THE YEAR FOR THREE STATIONS

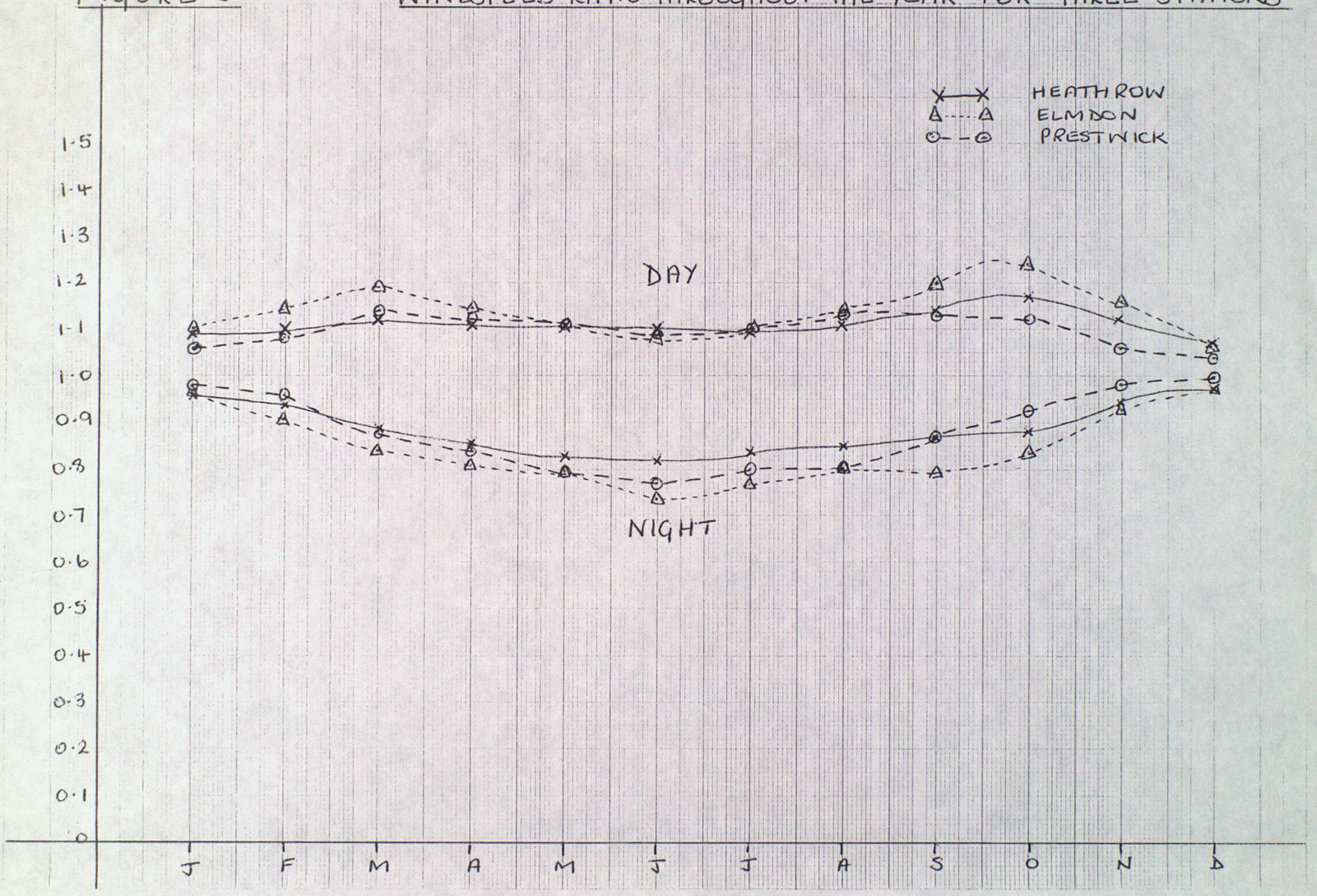


FIGURE 4

TEMPERATURE DIFFERENCE THROUGHOUT THE YEAR FOR THREE STATIONS

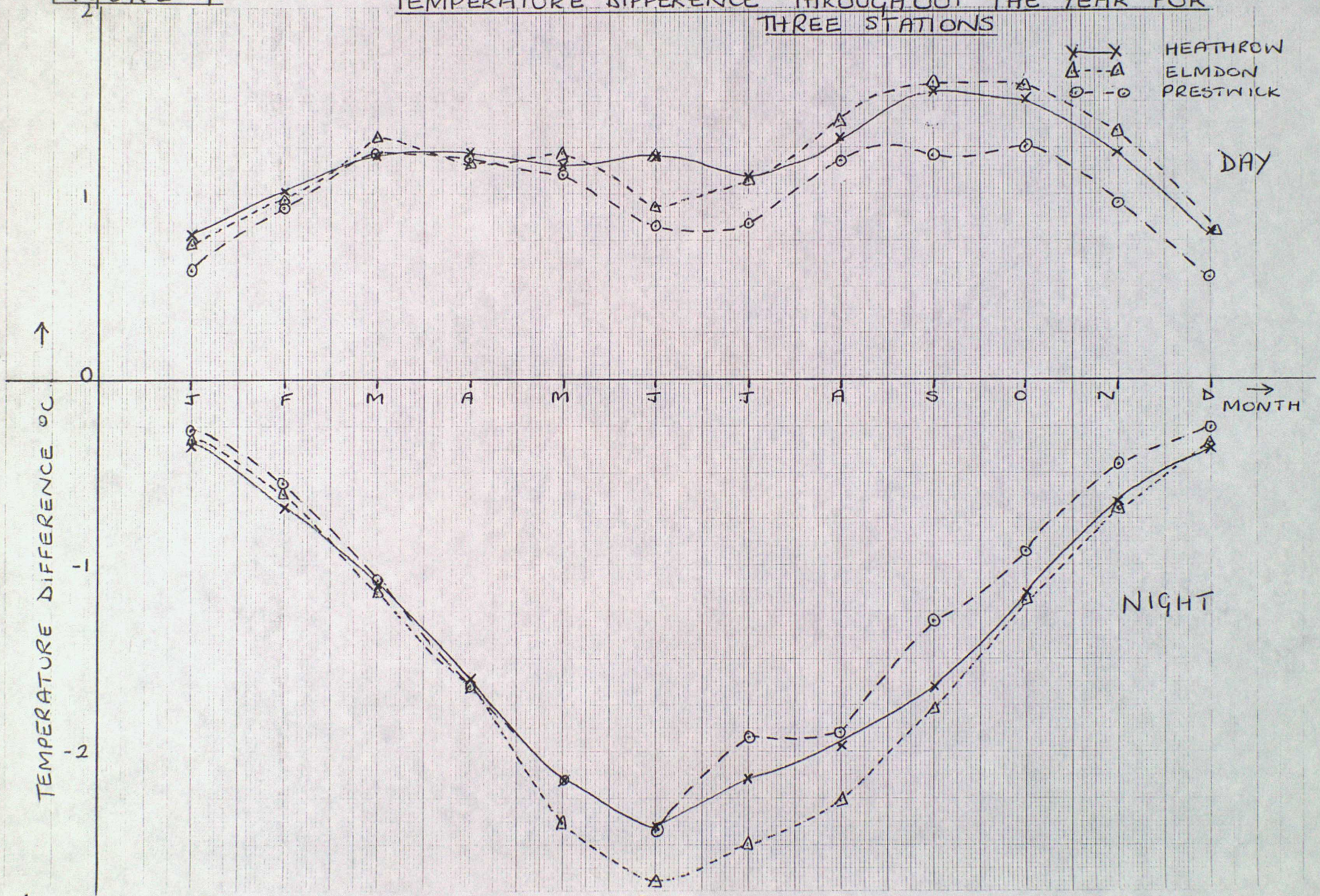
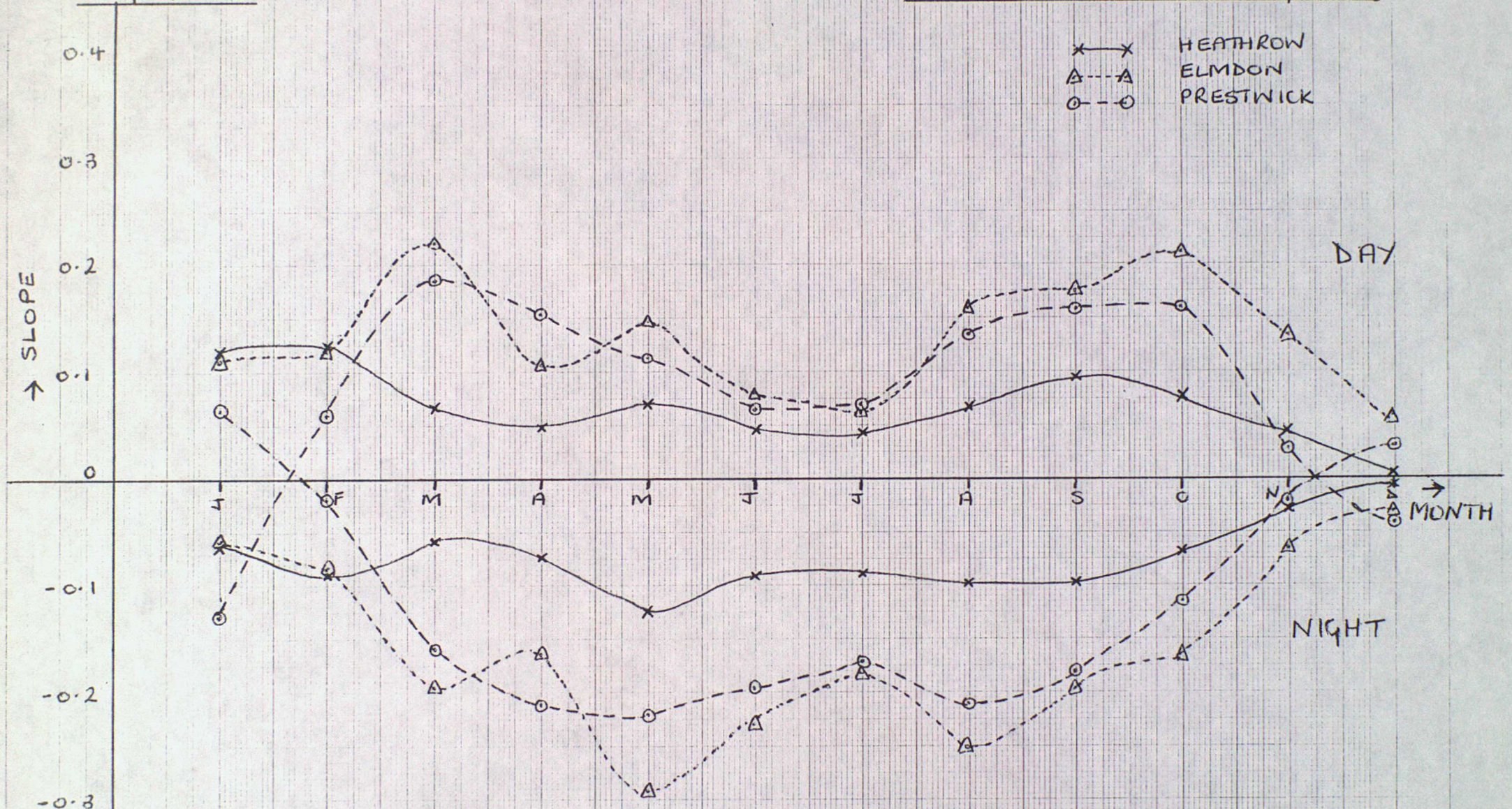


FIGURE 5

SLOPE OF WINDSPEED GRAPHS



The Heathrow readings seem to be significantly different from the others, an effect which, if it does exist, cannot at the moment be explained.

FIGURE 6

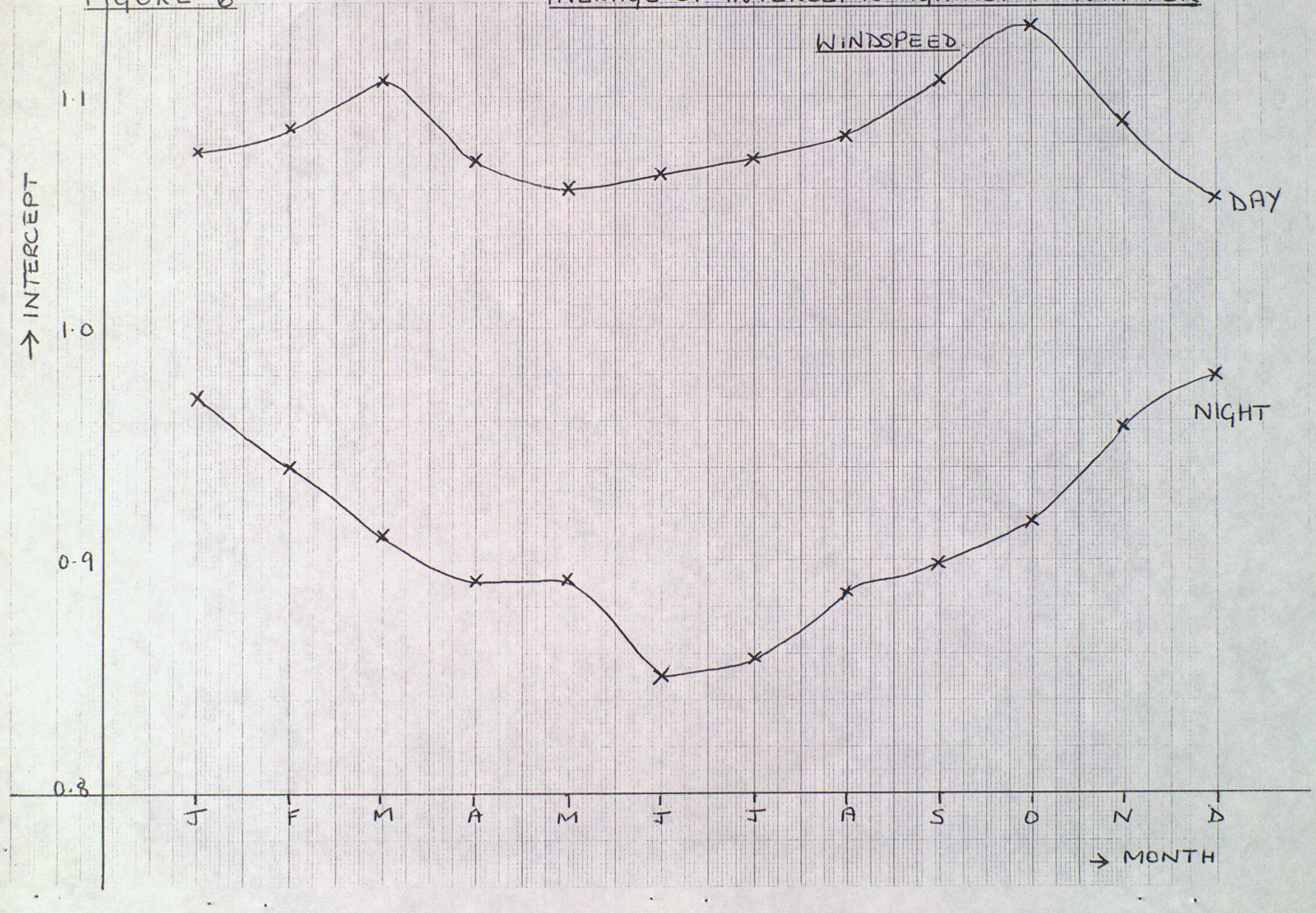

AVERAGE OF INTERCEPTS AGAINST MONTH FOR WINDSPEED
DAY
NIGHT
→ INTERCEPT
1·1
1·0
0·9
0·8
J
F
M
A
M
J
J
A
S
O
N
D
→ MONTH

FIGURE 7

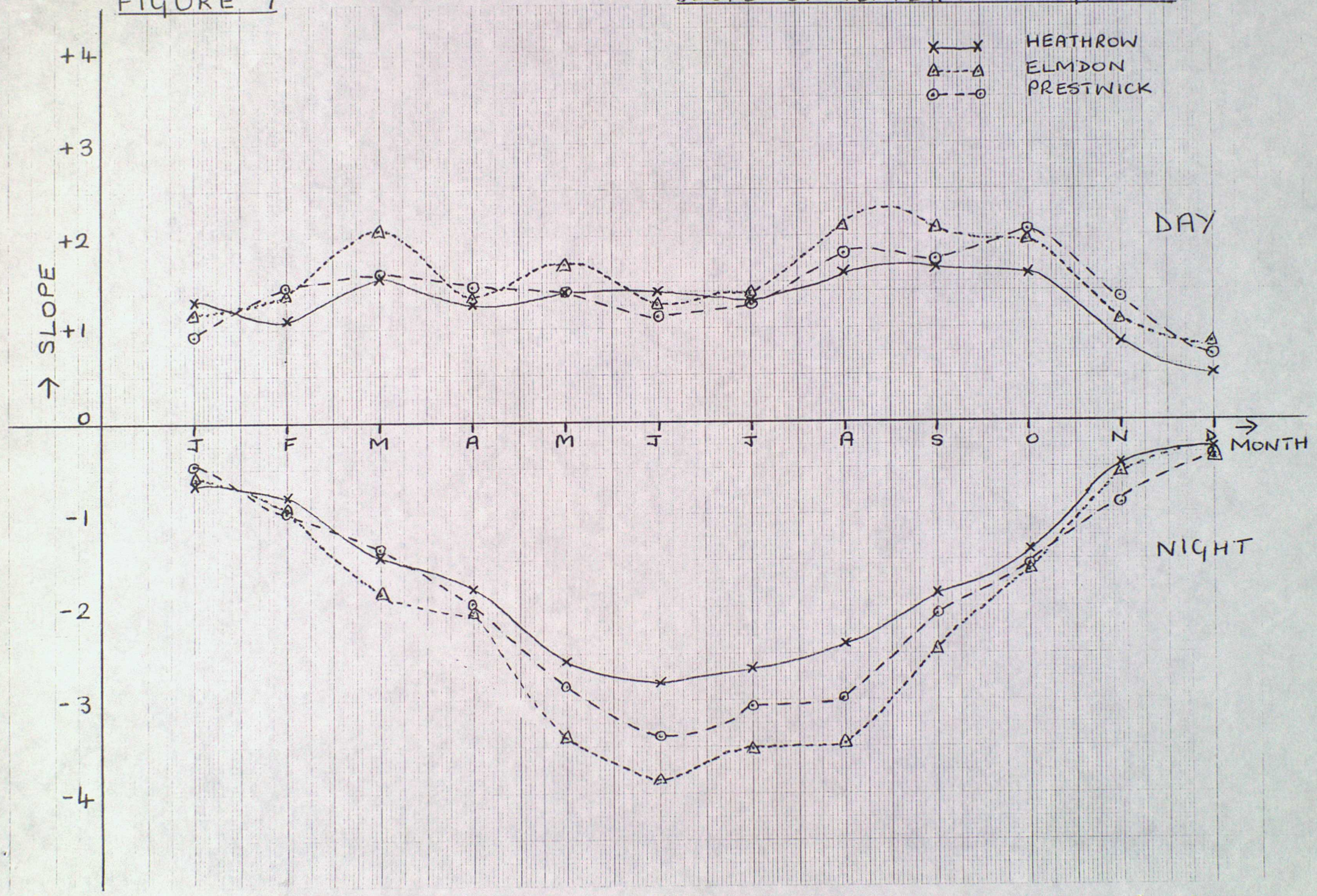

SLOPE OF TEMPERATURE GRAPHS
HEATHROW
ELMDON
PRESTWICK
+4
+3
+2
+1
0
-1
-2
-3
-4
→ SLOPE
DAY
NIGHT
J
F
M
A
M
J
J
A
S
O
N
D
→ MONTH

FIGURE 8

AVERAGE OF INTERCEPTS AGAINST MONTH.

FOR TEMPERATURE